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(54) Wireless system with digital transmission for loudspeakers

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(72) Inventor: Nathan, Guy  
91330 Yveras (FR)

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(74) Legal representative: Debay, Yves  
Cabinet Debay  
126 Elysée 2  
78170 La Celle Saint Cloud (FR)

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(73) Holder: TOUCHTONES MUSIC CORPORATION  
Las Vegas, NV 89104 (US)

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## Description

[0001] The present invention concerns a wireless digital transmission system for loudspeakers.

[0002] Wireless loudspeaker systems are known in which an analog audio signal is converted into a frequency modulation signal, this frequency modulation signal being transmitted over the alternating current supply lines of a domestic network. The signal received by the domestic network is then reconverted into an audio signal after extraction of the modulated frequency signal.

[0003] Such an arrangement is divulged by U.S. patent 4 829 570. This patent envisages, in addition, the use of a compression device to permit compression of the analog signals delivered by a compact disc reader, the wide dynamic range of which requires a very wide bandwidth to permit transmission in frequency modulation. The wide band and significant deviations pose numerous problems which are resolved in this document by the use of a compressor circuit to reduce the total dynamic range of the audio signal. This document allows us to be aware of a first difficulty, which is the limitation of stereophonic systems in particular using frequency modulation and functioning with analog systems such as variable frequency oscillators.

[0004] When we wish to move from simple stereophonic quality to stereophonic quality of the digital CD type, the quantity of information to be transmitted is such that we are very quickly limited in frequency modulation by bandwidth.

[0005] Finally, this type of system shown by U.S. patent 4 829 570 is acceptable for uses for private purposes on the domestic network of a personal residence but is difficult to install in an apartment building and even more so in a community or commercial development. In fact, music diffused on the supply network will be captured at the same time by all the loudspeakers installed and connected to the network. This poses a problem of regulation of copyright and it is thus desirable to provide a device which permits avoidance of a generalized diffusion.

[0006] Finally, such a device requires, to have two stereophonic channels, provision of a first carrier frequency for the first channel and a second carrier frequency for the second channel. These frequencies must be selected according to very precise conditions, which also limits the bandwidth possibilities.

[0007] A first goal of the invention is to propose a wireless system with digital transmission for loudspeakers which permits diffusion of stereophonic signals of digital compact disc quality and/or remote control.

[0008] This first goal is attained by the fact that the wireless system with digital transmission for loudspeakers comprises:

means for compressing the file representing the audio digital signal of the "Compact disc" type, a transmission device comprising means for transforming this compressed signal into a serial signal circulating in packets going to a phase-quadrature modulator circuit, and means for transmitting the signals leaving the phase-quadrature modulator circuit to the domestic electrical supply network;

a reception device comprising means for connecting to this domestic network and extracting from the electrical supply signal, using a phase-quadrature demodulator, the packets of information conveying the audio digital signal, transformation means for the packets of information in order to transform them into a parallelized digital signal sent to a decompression circuit,

means for transforming the decompressed digital signals into an analogue signal intended to supply a loudspeaker after suitable amplification.

[0009] A second goal is to permit the transmission of several musical signals intended for different loudspeakers.

[0010] This goal is attained by the fact that the means of serialization comprise means of inserting a destination address into the serialized signal packets, and in that the reception means comprise means for comparing the address shown in the received packet with the address specific to the reception device to which the loudspeaker is connected.

[0011] According to another particularity, the serialization device comprises means of multiplexing several frames of digital files representing a different audio signal to different addresses.

[0012] Another goal of the invention is to propose a system assuring that copyright cannot be infringed.

[0013] This third goal is attained by the fact that the transmission circuits comprise an encryption circuit and the connected reception device comprises a decryption circuit using a secret key stored in the memory of the deserialization circuit.

[0014] According to another particularity, the information from the digital signal is serialized according to a protocol comprising a first part constituting protocol information, a second part constituting the address of the recipient, a third part constituting the digital signal or the multiplexed digital signals, and a fourth part constituting end-of-protocol information.

[0015] According to another particularity, the protocol comprises a fifth part constituting control information for the loudspeakers.

[0016] According to another particularity, the protocol comprises a sixth part constituting at least one encryption key.

[0017] According to another particularity, the system comprises means for including control commands permitting individual adjustment of each loudspeaker, in the serial signal circulating by packet.

[0018] According to another particularity, the system includes means for converting an analog signal into a digital signal, arranged upstream of the compression means for the file representing the audio signal, when the audio signal to be transmitted is of the analog type.

[0019] Other characteristics and advantages of the present invention will appear more clearly upon reading the description below with reference to the attached diagrams, in which:

- Figure 1 represents a schematic view of the electronic circuit permitting implementation of the invention;
- Figure 2 represents a schematic view of an audiovisual system of the "jukebox" type in which the device of the invention can be used.

[0020] The invention will now be described in connection with Figure 1, in which the reference (13) designates the two conductors of a domestic network for the supplying of electrical energy to a building or premises designed to receive the public or a community such as for example a bar, a large store, a sports facility, etc. Connected to this electrical supply network is a transmission device (10) comprising the primary winding of a first transformer (108) which delivers by its secondary winding through a diode rectifier circuit a supply signal to a supply circuit (100) which extracts, from the alternating current signal of the rectified sector, the signals necessary for the supply of the various circuits of the device. In parallel, to the primary of this first transformer (108) is connected a second transformer (109), the secondary winding of which is supplied through a transistor by a phase-quadrature modulator circuit (101). This circuit (101) is supplied with voltage by the circuit (100) and receives from a microcontroller (102) flows of packets (P1, P2) of data representing digital information serialized according to a protocol (P) represented below. This protocol (P) comprises a first part (IP) constituting protocol information, a second part (AD) constituting the address of the recipient or addresses of each recipient, a possible third part (IC) constituting control information for the loudspeakers, a possible fourth part (CE) constituting an encryption key or several keys, each for one address, a fifth part (SNA) constituting the digital signal or the multiplexed digital signals, each signal being associated with one of the addresses of the recipient and finally a sixth part (IFP) constituting end-of-protocol information.

[0021] The signals are phase-quadrature modulated by the circuit (101) on a carrier, situated between 200 and 300 kHz, and are superposed on the alternating signal of the sector by the intermediary of the transformer (109). The digital audio signals coming from the audio source, after compression, represent a digital flow of 128 kilobits per second and are treated by the microcontroller (102) to be sent in successive packets according to the protocol (EP) specified above.

[0022] The program of the microcontroller (102) can be arranged to carry out the multiplexing of several audio sources, permitting for example the sending of a piece of classical music to a first loudspeaker while at the same time a piece of jazz music is sent to a second loudspeaker, each having a specific address and its own decryption key.

[0023] In this case, the device (10) addresses one or several frames to a user identified by a card or unit (11) connected to the loudspeaker. The transmission device (10) and the reception device or devices (11) are connected to each other only through the electrical conductors of the domestic electrical supply network.

[0024] Finally, when commands sent by a remote control unit (12) are received, transmitting for example a wave signal directed at a sensor (1020), the operating program of the microcontroller (102) permits the inclusion of the commands thus generated by this unit (12) in the package, so as to constitute the control information of the loudspeaker. This control information permits individual adjustment of each loudspeaker by adjusting the right channel, the left channel, the bass, the high notes, the volume, etc.

[0025] When one wishes to protect the audio information carried on the domestic network, so as to permit collection of royalties and prevent the same piece of music from being listened to by people who have not paid for it, one can add to the device an encryption circuit (103) placed between the compression circuit (104) and the microcontroller (102). In the case where the source of the musical signals is not of the digital type, an analog to digital converter (106) is added to the device, receiving at its input the output signals of an analog amplifier (107), which receives the analog audio signals.

[0026] The receiving device (11) is constituted as previously by a first transformer (118) permitting by means of a rectifier circuit the supplying of a supply circuit (110) designed to generate the supply signals necessary to the operation of the various circuits of the receiving device (11). A second transformer (119) connected to the primary of the first, by means of a decoupling capacitor, supplies a phase-quadrature demodulator (111), which provides at its serial output the protocol signals and the protocol packets to a microcontroller (112) which transforms these serial signals into parallel signals directed to a decryption circuit (113), the output of which is connected to a decompression circuit (114). The output of the decompression circuit (114) is itself connected to an analog digital conversion circuit (115), the output of which is designed to supply a loudspeaker (HP). The circuits for compression and decompression by an amplifier (116) apply an algorithm of the MPEG level 3 type, and the encryption (103) and decryption (113) circuits apply an algorithm of the MMPP (Multi Media Protection Protocol) type.

[0027] The microcontroller memory (112) of the unit (11) is loaded with the identification address which allows comparison of its address to the address received in the packet to identify whether the digital audio information is intended for it or for another loudspeaker. Likewise, the microcontroller memory is loaded at the time of initialization or during manufacture with a decryption key. Loading at initialization with the decryption key can be done by means of the fourth zone of the protocol.

[0028] The analog-digital converter circuits (ADC or DAC) for compression or encryption and amplification of the transmission device (10) can be realized, for example, by a digital signal processor commercialized by Motorola under the reference 563XX and commonly called DSP (Digital Signal Processor).

[0029] Likewise, the circuits for decryption, decompression and digital-analog conversion of the receiving device (11) can be realized in a digital signal processor commercialized by Motorola under the reference 563XX and commonly called DSP (Digital Signal Processor).

[0030] One can thus, by means of such a device, permit the installation of multiple loudspeakers in different premises provided they are supplied by the same phase of the network to which the transmission device (10) will be connected. This transmission device (10) must on one hand be connected to an audio signal source, which may be for example the digital output of a compact disc reader or the digital output of a jukebox hard disk such as that described in Figure 2 and corresponding to the patent request PCT FR 95 01333 published under number WO 96/ 12 256, and on the other hand to conductors of the electrical supply network of the building or premises. The jukebox in Figure 2 is constituted by a central unit (1), a microprocessor which is a system compatible with a high performance PC. Upon implementation the choice was made of a system of the Intel 80486 DX/2 type which has storage means and the following characteristics:

- compatibility with Vesa local bus
- processor cache memory: 256 KB
- high-performance serial and parallel ports
- SVGA microprocessor graphic adapter
- self-supplied static RAM

[0031] Any other central unit having equivalent or superior performance may be used in the invention.

[0032] This central unit controls and manages a sound control circuit (5), a telecommunications control circuit (4), an input control circuit (3), a mass memory control circuit (2), and a visualization means control circuit (6). The visualization means are composed principally of a high-resolution low-radiation non-interlaced SVGA 14-inch (35.56 cm) flat-screen video monitor (62); it is this monitor which is used for the reproduction of images (for example, album covers of musical selections), graphics or video clips.

[0033] Mass storage means (21) using high speed and high capacity SCSI hard disks are associated with the storage means already present in the microprocessor device. These means serve for the storage of digitized and compressed audiovisual information.

[0034] A high-speed 28.8 kbps telecommunications modem adapter (41) is integrated to authorize liaison with an audiovisual information distribution network controlled by a central server.

[0035] For the reproduction of the sound information of the musical selections, the system comprises loudspeakers (54) receiving the amplifier-tuner signal (53) connected to an electronic circuit (5) of the musical synthesizer type designed to support a large number of input sources while providing an output presenting CD-type quality such as, for example, the "Sound Blaster" SBP32AWE microprocessor multi-media audio adapter from Creative Labs Inc., on which two memory buffers (56, 57) are added for the purpose specified above.

[0036] Likewise, the visualization means control circuit also comprises two buffers (66, 67) for the purpose specified above.

[0037] A thermally regulated ventilated 240-watt supply provides energy to the system. This supply is protected against surges and ringing.

[0038] The audiovisual reproduction system manages, through its input control circuit (3) a 14-inch (35.56 cm) "IntelliTouch" touch screen (33) from Elo Touch Systems Inc., which includes a glass panel using "advanced surface wave technology" along with an AT bus controller. When affixed to the video monitor (62) or a television screen (61), this touch screen permits diverse selection information used by the customers, as well as management command and control information used by the manager or owner of the system. It is also used for maintenance purposes in combination with an external keyboard (34) which can be linked to the system, which has for this purpose a keyboard connection, controlled by a lock (32) through the interface circuit (3).

[0039] The input circuit (3) also interfaces with the remote control system (31) constituted for example:

- by an infrared remote control from Mind Path Technologies Inc., a transmitter having 15 command keys for the microprocessor system and 8 command keys for the projection device;
- by an infrared receiver with serial adapter from Mind Path Technologies Inc.

[0040] A royalty payment device (35) from National Rejectors Inc. is also linked to the input interface circuit (3). It is also possible to use any other device which permits receipt of any means of payment by coins, bills, tokens, magnetic chip cards or a combination of means of payment.

[0041] To hold the system, a steel frame or rack with customizable exterior fittings is also provided.

[0042] In addition to these elements, a wireless microphones (55) is linked to the sound controller (5), which transforms the latter into a powerful system for announcements and information directed to the public or possibly a karaoke machine. Likewise, a system of wireless loudspeakers can be used by the system.

[0043] This remote control assembly (31) allows the manager, for example from behind the bar, to access and control various commands such as:

- the microphone on-off command
- the loudspeaker mute command
- the volume control command
- the cancel command for the musical selection being played

[0044] Two buffers (56, 57) are associated with the sound controller circuit (5) to permit storage, each alternately, of information corresponding to a quarter of a second of sound. Likewise, two buffers (66, 67) are associated with the video controller circuit (6), each capable alternately of storing a tenth of a second of images. Finally, one buffer each (48, 36, 28) is associated with the communication controller (4), input interface (3) and storage (2) circuits respectively.

[0045] The digitized and compressed audiovisual data is stored in the storage means (21).

[0046] This information is transmitted by the intermediary of the central unit (1) on the card (105) to which are added the elements corresponding to the circuit (10), the encryption circuit (103) being directly connected to the buffer circuits (56, 57) in the case where the information is already compressed, either by a first connector (1021), avoiding the encryption circuit (103) if the information is already encrypted or does not need to be, or by a second connector (1031), using the encryption circuit (103), if the information must be encrypted. In the case where the information is not compressed, the buffers (56, 57) will be connected to a third connector (1041) so as to use the compression circuit.

[0047] Thus, by connecting the transformer output (106) to the sector, it is possible by connecting the reception circuits (11) to different places in the sector to supply different loudspeakers remotely, in addition to the loudspeakers normally provided in the jukebox system (54). This will permit diffusion of good-quality sound in different premises while assuring the manager the possibility of regulating volume according to the premises or the placement of the loudspeakers.

[0048] In the case where the invention is used on another device such as a compact disc reader, radio for reception of specialized channels, etc., it is possible to equip the device with one of the payment means described above for the jukebox application, which as for the jukebox permits operation of the reception device only after the fee is paid and for the duration prescribed for the fee. This duration is determined by a clock associated with the reception device.

## Claims

1. Wireless digital transmission system for loudspeakers comprising:

means for compressing the file representing the audio digital signal of the "Compact disc" type, a transmission device comprising means for transforming this compressed signal into a serial signal circulating in packets going to a phase-quadrature modulator circuit, and means for transmitting the signals leaving the phase-quadrature modulator circuit to the domestic electrical supply network;

a reception device comprising means for connecting to this domestic network and extracting from the electrical supply signal, using a phase-quadrature demodulator, the packets of information conveying the audio digital signal, transformation means for the packets of information in order to transform them into a parallelised digital signal sent to a decompression circuit;

means for transforming the decompressed digital signals into an analogue signal intended to supply a loudspeaker after suitable amplification.

2. Wireless digital transmission system for loudspeakers according to Claim 1, **characterised in that** the serialisation means comprise means for inserting a destination address into the packets of serialised signals; and **in that** the reception means comprise means for comparing the address shown in the received packet with the address specific to the reception device to which the loudspeaker is connected.

3. Wireless digital transmission system for loudspeakers according to Claim 1 or 2, **characterised in that** the serialisation device comprises means for multiplexing several frames of digital files representing a different audio signal to different addresses.

4. Wireless digital transmission system for loudspeakers according to Claim 1, **characterised in that** the transmission circuits comprise an encryption circuit and the connected reception device comprises a decryption circuit using a secret key stored in the memory of the deserialisation circuit.

5. Digital transmission system for loudspeakers according to Claim 1 to 4, **characterised in that** the information from the digital signal is serialised according to a protocol comprising a first part (IP) constituting protocol information, a second part (AD) constituting the address of the recipient, a third part (SNA) constituting the digital signal or the multiplexed digital signals, and a fourth part (IFP) constituting end-of-protocol information.

6. Digital transmission system for loudspeakers according to Claim 5, **characterised in that** the protocol comprises a fifth part (IC) constituting control information for the loudspeakers.

7. Digital transmission system for loudspeakers according to Claim 5, **characterised in that** the protocol comprises a sixth part (CE) constituting at least one encryption key.

8. Digital transmission system for loudspeakers according to Claim 1 to 7, **characterised in that** it comprises means for including control commands permitting individual adjustment of each loudspeaker, in the serial signal circulating by packet.
9. Digital transmission system for loudspeakers according to Claim 1 to 7, **characterised in that** it includes means for converting an analogue signal into a digital signal, arranged upstream of the compression means for the file representing the audio signal, when the audio signal to be transmitted is of the analogue type.

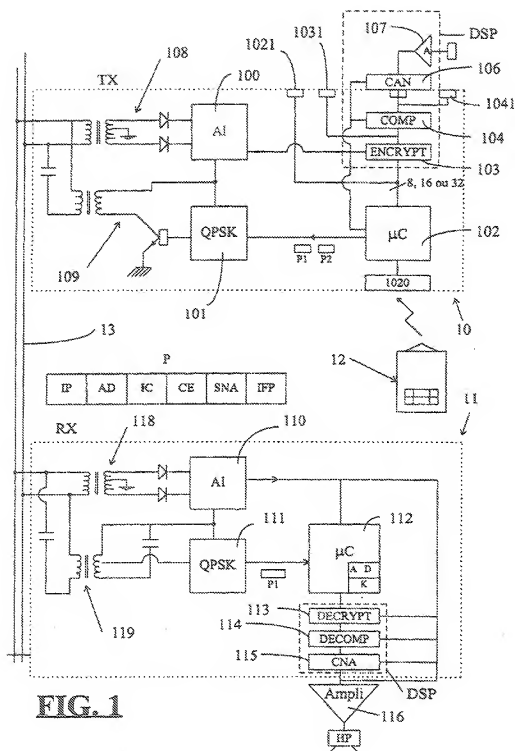


FIG. 1

